With regard to instruments, the reflecting prismatic camera has proved to be a most efficient form of spectrograph for eclipse work.

The uniform focus over the entire range of spectrum, and the facility with which the adjustment for focus can be effected, are advantages which those who have worked with prismatic cameras will appreciate.

Another important advantage in the use of the reflector is the proximity of the exposing shutter to the plate holder, both of which can easily be controlled by one person. There is no signalling between the man at the plates and the man at the shutter.

There is again the advantage that there is no selective absorption of ultra-violet rays which occurs in lenses, and if the mirror is freshly polished there is no selective reflection for any of the rays which can be photographed.

In concluding, I have to acknowledge my great indebtedness to my brother for his untiring devotion to the interests of the expedition throughout. In all the negotiations necessary on arrival in the country he took a leading part, and was successful in obtaining the goodwill of every person with whom we came in contact.

The fine series of photographs which we obtained bear witness to his skill in carrying out, to the letter, the somewhat troublesome arrangements which I had planned for erecting and adjusting the instruments.

"Preliminary Note on Observations of the Total Solar Eclipse of 1900 May 28, made at Santa Pola (Casa del Pleito), Spain." By RALPH COPELAND, Ph.D., F.R.A.S., F.R.S.E.—Read at Joint Meeting of the Royal and Royal Astronomical Societies, June 28, 1900. MS. received October 1, 1900.

I had again the honour of being nominated one of the observers for the Joint Eclipse Committee, the station allotted to me being at Santa Pola, on the south-east coast of Spain.

On the 9th May I left Edinburgh, and sailed from Tilbury on the 11th in the Orient steamship "Oruba," accompanied by Mr. Thomas Heath, First Assistant at the Edinburgh Royal Observatory, who was going to Santa Pola to observe the eclipse on behalf of the Royal Society of Edinburgh.

My instrumental outfit had preceded me under the care of Mr. James McPherson, the experienced mechanician of our Edinburgh observatory. This outfit comprised the 40-foot horizontal telescope of 4-inch aperture previously used in India and Norway, together with a small Iceland spar and quartz prismatic camera, with an effective aperture of 1·8 inch.

At St. Pancras Station I had the pleasure of joining Sir Norman Lockyer and his party, who, like ourselves, were bound for Santa Pola.

Early on the 16th we reached Gibraltar, where we were met by another member of our Edinburgh party, Mr. Franklin-Adams, from Machrihanish, who had most thoughtfully arranged for the transfer of all our eclipse apparatus from the "Oruba" to H.M.S. "Theseus," which the Admiralty had generously placed at the disposal of the Joint Committee. We were most cordially welcomed on board the "Theseus" by Captain Tisdall, who introduced us to his officers, and assigned to us our most comfortable quarters.

The few days spent on board the "Theseus" passed most pleasantly. With the greatest interest we followed the various forms of drill, and were greatly struck by the promptitude and precision with which every order was carried out.

On landing at Santa Pola on the afternoon of the 17th we were received with the utmost courtesy by the Alcalde and other Spanish authorities, who at once assured us of all possible assistance in the furtherance of our work. The interchange of courtesies being over, we at once proceeded to the camp already laid out for Sir Norman Lockyer's party. Abundant space had been left for the installation of our apparatus, but on closer examination of the ground we found the subsoil too light and sandy to afford the firm foundation required by our heavy instruments. We had therefore to select another site. This we found in the upper part of the town, in a barley-field, from which the crop had been gathered a few days before. Here the solid rock, covered only by a thin layer of soil, afforded an ideal foundation for all our apparatus, while the neighbouring walls or houses protected the site from the prevailing winds without unduly obstructing the view.

To the south-east of the selected spot stood a large barn, which chanced to be vacant in consequence of a law suit, and was therefore called "La Casa del Pleito." This barn was allotted to us by the ever-obliging Alcalde, and gave the name to our station. It served in the threefold capacity of a store-place for our empty boxes, a photographic laboratory, and a most welcome retreat from the burning rays of the noonday sun.

While our instruments were being landed and carted up on the morning of the 18th, we commenced laying out and preparing the necessary foundations for them. In this, as in all our work, we were most efficiently helped by a detachment of junior officers and men from the "Theseus."

For the first few days there was a good deal of cloud, by night as well as by day, and it was only with difficulty that the exact observations requisite for setting up the 40-foot were secured.

Saturday, the 19th, was a red-letter day for us, as well as for our countrymen throughout the world. With his usual thoughtful care,

Mr. Franklin-Adams, before leaving England, had arranged that a concise daily telegram should be sent to him giving the latest war news. These telegrams were at once communicated to both camps as well as to the "Theseus," and it is needless to say with what keen interest they were received and discussed. We were preparing for lunch at the comfortable little restaurant where we lodged when the telegram announcing the relief of Mafeking was received. Immediately we all rushed into the entrance hall, where we gave three hearty British cheers, greatly to the astonishment of our Spanish friends, who were quite at a loss to understand what all the cheering and excitement meant.

By Monday the 21st all our heavier concrete foundations were finished, and we had a clear week in which to adjust and test our appliances. The weather had also become much clearer, particularly in the afternoon, when it was important to check the final adjustments of the long telescope at the hour corresponding to that of the eclipse. Eventually all the adjustments were completed and tested by the 27th, on the afternoon of which day we had the satisfaction of seeing the sun's image traverse the plate-holder of the 40-foot precisely at the computed rate, and at the exact distance from the centre line corresponding to the sun's declination at the time.

On the 26th we received a visit from the Civil Governor of the Province of Alicante, who was desirous of seeing our apparatus and satisfying himself that everything possible was being done for our comfort and convenience. On the same day a party of French astronomers came over from Elche to see our camp and compare notes. We much regretted that time did not permit our returning their friendly visit.

Meanwhile, Mr. Heath and Mr. Franklin-Adams had erected the equatorial stands to carry their apparatus. Mr. Heath was provided with a 6-inch photo-visual telescope by T. Cooke and Sons, arranged to photograph the corona in the primary focal plane; while Mr. Franklin-Adams' equipment consisted of a number of cameras, several of them of large aperture, designed for obtaining pictures of the coronal rays and the sun's surroundings generally. He had also several very accurate thermometers mounted on a suitable screen.

The exact duties of each member of the camp were repeatedly rehearsed in accordance with the beats of a metronome, the indications of which were shouted out by a seaman on the plan devised by Sir Norman Lockyer for regulating the numerous operations at his camp. As most of the observers had already practised at their respective instruments, even the first general rehearsal went off much better than we could have expected. The whole credit of this is due to our naval assistants, who, from being trained to act promptly and in concert, readily appreciated the exact nature of the new duties entrusted to them.

In the night all the plate-holders were duly filled and arranged in order.

For about a week before the day of the eclipse the closely approximate time of Greenwich mean noon was signalled to us from the ship. This proved of the greatest value, as it relieved the camps of the necessity of making independent time determinations.

From the moment at which the erection of the instruments was commenced four members of the "Guardia Civil" were told off by the Spanish authorities to watch over the safety of our gear. A single wire cord stretched round the area occupied by the instruments served as the line of demarcation, within which unauthorised persons were not allowed to come. On the day of the eclipse this line was thrown somewhat farther back at the suggestion of our Spanish friends.

The weather on the momentous 28th was all that astronomers could desire. With the greatest care all our apparatus was revised. The end of our barn had been smoothed over with stucco so as to present a white expanse some 30 feet in width by 15 feet in height on which to observe the shadow bands. The azimuth of this wall was very exactly S. 40° W., and as mid-totality occurred in azimuth 92° 10′, the position of the wall was very favourable for the observations in question. We also put up a white screen some 14 feet square, projecting at right angles to the northern end of the wall, and whitened the ground in the angle thus enclosed, thereby giving three planes on which we hoped the bands might be seen. Two officers of the "Theseus," who for some days previously had practised marking and recording imaginary shadow bands, were entrusted with the duty of recording the real bands as they appeared on the white surfaces. They were provided with brushes attached to long poles, and with pots of coloured wash—blue for the beginning of totality and red for the end.

I undertook to observe the first contact with a small telescope of 2 inches aperture.

This occurred $10^{s}\cdot4$ before the computed time, but the discrepancy caused no surprise, as the moon's limb was very rough at the point of contact, and there was the chance that our chronometer-time might be out a second or two. In view of the very important work before us, no photographs of the partial phase were attempted.

I have a note that at twelve minutes before totality the sky began to darken very rapidly, the darkness increasing more and more visibly during the last minutes before the total phase. Five minutes before totality, at the word "Stations," everyone took up his assigned post. The large crowd of spectators who had collected during the last hour or two pressed closer in to the boundary wire—some of them still expressing their doubts as to whether the eclipse would really be total or not.

Eighty-three seconds before the computed time of second contact I

gave the signal "Start the clock" to McPherson, who was in the dark room of the 40-foot. At this moment Mr. Franklin-Adams gave a few strokes on a large bell, and called out "*Silencio!*" I must here say that this call was immediately obeyed in the most courteous way by the assembled crowds, who maintained a perfect silence until the important phase was over.

One minute before totality, at the signal "Chronograph," McPherson registered the position of the moving plate-holder. Sixteen seconds before totality, when, according to Mr. Fowler's computation, the diminishing crescent should subtend an arc of 90°, I gave the signal "Stand by;" five seconds before totality, corresponding to 55° of a crescent, the signal "Ready" was called, and at the disappearance of the last glimpse of sunlight I gave the final signal of "Go!"

From this moment the sailor in charge of the metronome announced every fifth second during the first minute, and then every second until the seventy-fifth, when he called "Stop!"

One minute and twenty-four seconds after the signal, I gave to McPherson the final signal "Chronograph," which he again recorded on the moving plate-holder, assuring himself at the same time that it was still moving at the regular speed. While I was giving the earlier signals just mentioned, I noticed a very interesting feature in the diminishing crescent. When the luminous crescent was reduced to a mere line, an exceptionally brilliant bead of light became detached from the rest, continuing to shine like a bright star for perhaps four or five seconds, and probably disappearing nearly at the same time as the rest of the crescent. It was doubtless due either to the passage of the sunlight through a very deep valley on the moon's limb or to the interruption of the crescent by a high range of lunar mountains. Whatever its origin it presented an extreme case of the well-known phenomenon of "Baily's Beads."

What struck me most, both in the late eclipse and in that of 1898, was the sudden transition from the swiftly changing phenomena attendant on the disappearance of sunlight to the steady unvarying aspect of the corona. During the last few minutes of the partial phase all the phenomena are in a state of rapid change—the light decreases in a swift geometrical ratio, the last shred of the sun's limb disappears, the prominences burst into view, and all at once the corona stands before one fixed and relatively unchanging during the whole of totality.

The corona, as seen with the naked eye, presented a striking resemblance to the pictures of the corona of 1878. Below was a broad double streamer, like the outspread tail of a dove, symmetrical to the sun's equator, while opposite to this was a single large pointed streamer involved in a much fainter dove-tail symmetrical to the one below. The spectrum shown by an excellent direct-vision prism about mid-

totality struck me as being very continuous, for I did not see the K 1474 ring. In common with all other observers, I was struck by the extreme brightness and the red colour of Mercury some $2\frac{1}{2}^{\circ}$ preceding the Sun, while near the zenith Venus blazed in the purest white.

Turning to the photographic results, three successful negatives of the prominences and the corona were obtained with the 40-foot, with exposures of $5^{s}\cdot0$, $18^{s}\cdot6$, and $3^{s}\cdot0$ respectively. On the whole, the long exposure gives the best picture; in the original negative the light of the great equatorial streamers can be traced to a distance of about one solar diameter from the moon's limb, while the detail of the shorter streamers is shown with considerable precision. The short exposures naturally bring out the shorter rays that are to some extent lost in the brightness due to the long exposure.

There are also twenty-four spectrograms taken with a direct-vision prism drawn in front of the object glass of the 40-foot. Of these, two groups of ten each were secured, one set as totality was coming on and the other immediately after it had ended. They were taken on plates measuring 8 inches by 16 inches, so arranged as to be moved transversely in the plate-holder between each exposure. The "height" of each spectrogram is 0·3 inch, while an interval of $\frac{1}{2}$ inch is allowed between the different pictures. The remaining four spectrograms were taken after totality with the 40-foot acting as a prismatic camera. The two earlier ones show H, K and other lines extending beyond the continuous spectrum, while the two last are of little interest except for finding how long after the end of totality it is possible to obtain useful spectrograms.

In developing these plates, and in making the copies and slides* from them, we had the advantage of the skilful assistance of Mr. John Banks, photographer, of Edinburgh.

McPherson's position inside the dark room of the 40-foot gave him the unique opportunity of watching the actual image of the sun's appendages as it imprinted itself on the sensitive films. At the time of making the exposure of nearly nineteen seconds at mid-totality he describes the picture as comparatively dark—very little of the corona being visible; the larger prominences were, however, noticed, although they were not nearly so bright as afterwards. In the last exposure, near the end of totality, the prominences appeared of a bright flaming red colour, and the picture on the plate was altogether a splendid sight. Mr. McPherson was watching the prominences under the impression that there were still five seconds to spare, as the time-keeper at the metronome was counting seventy, and we expected the eclipse to last seventy-five seconds, when all at once a sudden increase

* The best of these slides, as well as contact copies of the larger negatives, were exhibited at the meeting.

of brightness took place on the moon's limb—white light seeming to curl over the edge of the moon's disc. Immediately concluding that the total phase was all but over, he let go the cord and closed the shutter. When working with the prism the exposures were far too short to permit of seeing the images.

The spar camera was in charge of William Slaughter, petty officer of the "Theseus"; it could not possibly have been in better hands, for in spite of the lightness of the 3-inch equatorial mounting and the delicate clock movement by which it was carried, he exposed all his plates without deranging the instrument in the slightest degree. Six spectrograms were obtained in all, several of which contain many ultra-violet lines belonging to the chromosphere, or possibly to the lower layers of the corona.

Pending the presentation of the report on the shadow-bands which is in my hands, but which I should like to supplement by a short computation, I may say that the two officers of the "Theseus," Mr. Green and Mr. Alexander, succeeded in marking the course of the shadow-bands on the vertical wall both at the beginning and at the end of the total phase. As totality came on, the faint rippling bands moved to the right upwards, the direction of motion making an angle of 20° to 30° with the vertical; at the end of the dark phase the motion was in the opposite direction—to the left downwards—the motion in both cases being at right angles to the lines. The lines appeared in short wavy fragments. Quite at the last, a little after the main body of the lines had disappeared, there came a solitary thicker line, more distinct than the rest, and moving less rapidly in a direction inclined 47° to the vertical, but otherwise in the same general direction as the rest of the lines. The wall was photographed, but although the negative shows the red lines distinctly enough, the full blue colour used at the beginning of totality, can scarcely be seen in the photograph. No bands were satisfactorily made out on either of the two other planes.

The warmest thanks of our party are due—to the Admiralty for all the assistance given to us; to the officers and crew of H.M.S. "Theseus" for their hearty co-operation, which contributed so largely to the success of our endeavours; to the British Vice-Consul at Alicante; to the Spanish authorities and to our Santa Pola friends for their untiring courtesy and kindness; and to the "Orient" Steamship Company for their very liberal concession in carrying our bulky impedimenta practically free of cost.